Iranian Journal of Fisheries Sciences 15(3) 1078- 1088 2016

The effect of dietary dextrin levels on growth performance, body composition and hepatosomatic index in juvenile Siberian sturgeon, *Acipenser baerii*

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Received: May 2015 Accepted: August 2015

Abstract

The present study was carried out to determine the ability of *Acipenser baerii* in utilizing carbohydrate (dextrin) as a non protein energy source substituted with animal oil. A total of 65 juveniles *A. baerii* with an initial mean weight of 689 ± 62 g were distributed in 15 fiber glass tanks. Five diets were formulated including 0, 5, 10, 15 and 20% of dextrin and fed for 8 weeks. Fish were weighed monthly and growth was evaluated in each treatment. At the end of experiment, body composition and hepatosomatic index were analyzed. There was no significant differences in body weight increase (BWI) and final weight (FW) among different groups (p>0.05). Increase of dextrin levels in diets led to an increase in feed conversation ratio (FCR) in fish fed diets containing 15 and 20% dextrin as compared to that in the control group and in fish fed the diet containing 10% dextrin although the differences were not significant (p>0.05). The specific growth rate (SGR) in all treatments were the same (p>0.05). The highest body protein and lipid were observed in fish fed diets containing 10 and 20 % dextrin, respectively (p<0.05). The hepatosomatic index (HSI) showed no significant differences in experimental groups compared to the control (p>0.05). In conclusion, juvenile *A. baerii* can be fed diets with high levels of dietary dextrin as a non protein energy source with no deleterious effects and a partial replacement of cheap carbohydrate with lipid is suggested to obtain the necessary energy in commercial diets.

Keywords: *Acipenser baerii*, Lipid, Carbohydrate, Growth rate, Body composition.

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Introduction

Protein, lipid and carbohydrate are the main energy sources in animals. Lipid sources for fish are fish oil and plant oil. Carbohydrate sources are divided into simple and complex based on their molecular complexity and processing method. Aquatic animals obtain most of their acquired energy from lipids, carbohydrates and protein sources (Lovell, 1989).

Protein (fish meal) and lipid (fish oil) used in diet is an expensive ingredients and its value was increased because of decreasing pelagic fishes capture (Jackson, 2007). But, carbohydrate is the cheapest source of energy that is used in animal food extensively and there are many intrested in replacement of it with lipid source (fish oil) in aquatic animals diet for thriftness (Aikins *et al*., 1992). The utilization of simple carbohydrates such as glucose led to an increase in glucose, constant hyperglysimi and anoretic in them (Palmer and ymon, 1972; Bergot, 1979; Furuichi and Yone, 1981, 1982).

The highest dextrin utilization in *Seriola quinqueradiata* and *Cyprinus carpio* was at 20 and 30 %, respectively (Millikin, 1982). Also, the increase in carbohydrate in diets led to the activation of lipidogenesis enzymes in *A. baerii* and an increase in body lipid (Kaushik *et al*., 1989).

Food comprised 50% of total costs in the economical rearing of sturgeon. With regard to high food conversion ratio (FCR) and long term rearing, food costs must be decreased. One of these methods is replacing a suitable source of carbohydrate instead of fish oil in diets and determinig suitable protein to carbohydrate ratio in fish diets. There are no reports available on the ability of *A. baerii* to utilize carbohydrates in Iranian conditions.

This study was carried out in order to evaluate and identify the utilization of carbohydrate (dextrin) as an energy source substitued with lipid (fish and plant oil) and also to study the effect of this carbohydrate source on growth, body composition, hepatosomatic index and visceral index in *A. baerii*.

Material and methods

Experimental fish

A total of 150 juvenile *A. baerii* (mean weight 500 to 1200 g) were selected from two fiberglass tanks (2000 L) and 60 of them (with mean 689.3 ± 61.96 g weight) were separated and stocked in 15 fiberglass tanks (500 L) (4 fish per tank) equiped with aeration system, input and output canals. The water was supplied from the Sepidroad River that was pumped into fiberglass tanks. The lighting of the rearing site was 12 hours of light and 12 hours of darkness using natural light and flourecent lamps.

Feeding trails

In order to measure the ability of *A. baerii* (at growth stage) to utilize different levels of carbohydrate as a new source of energy and to detemine the the ideal level of substitution, 5 commercial diets with the same levels of protein (42 %) and energy (24.3

MeJ/ kg) (based on 10 % of plant and animal oil used in diet and fish meal lipid) were provided and then 5, 15 and 20 % of dextrin was added to diets based on the energy from carbohydrate sources (4.2 kcal/g) substited with plant and animal oils (9.45 kcal/g) as shown in Table 1.

Experimental diets and Sample collection

All ingredients (fish meal, soybean, meat meal, dextrin and etc.) were crushed and powdered with a miller for 20 minutes and then textured using a mixer. Little amount of vitamin premix, mineral supplement and other additives were added to each kg of dry diet in 700 cc dilute water, dried for 20 minutes and then oil (plant and animal) was added to it and mixed to produce a homogenically dry diet. Oil (plant and animal) was added to the new composition and mixed for 15 minutes and then it was filled in the granule producing machine.

Granules were dried in a drier set at 50 ^{o}C for 24 hours, packaged, marked and stocked in a freezer -20 ^{o}C. One hour before distributing food to tanks, diets were defreezed, weighed and fed to fishes at a rate of 3% body weight, 4 times daily. Physicochemical parameters such as temprature and pH were measured daily. Biometry of fishes was carried out once every two weeks. At theend of the rearing period (after 8 weeks), 30 % of fish from each treatment was sampled and their carcass transferred to the lab for chemical analysis of protein, fat, mpoisture and ash. Carcasses from all fish were ground and homogenised, and their body composition was analysed.

Chemical analysis

Chemical composition of ingredients, experimental diets and carcass of fishes were analyzed using AOAC (1990) standard methods.

Protein was measured by Kjeldhal method. Oil was extracted by Soxhelet method using chloroform solvent (boiling point 50–60^{o}C) for 4–6 hours. Ash was measured by burning samples at 550^{o}C for 9 hours. Total energy of particles and diets was measured by calorimeter bomb set.

K(%) = (BWF/ TL^{3}) ×100 (Martinez-Liornes *et al*., 2007)

%BWI = 100 × (BWf - BWi)/BWi (Hung *et al*., 1989)

F.C.R = F/(Wt-W0) (Ronyai *et al*., 1990)

S.G.R = (lnWt -lnW0)/t ×100 (Ronyai *et al*., 1990)

PER= (Bwf-Bwi)/protein intake (Xue *et al*., 2006)

HSI = (Liver weight / body weight) ×100 (Hillestad *et al*., 2001).

Table 1: Results of Physicochemical parameters during 8 weeks.

Mean ± EM	1th week	2th week	3th week	4th week	5th week	6th week	7th week	8th week
Dissolved oxygen (mg L^{-1})	6.1 ± 0.1	6.1 ± 0.2	6.1 ± 0.2	6.1 ± 0.3	6 ± 0.3	7.1 ± 0.3	6.5 ± 0.2	6.2 ± 0.3
Temperature (^{o}C)	18.9 ± 1.2	15.5 ± 1.2	15.9 ± 2	15.9 ± 1.2	15.6 ± 1	15.1 ± 1.2	15.8 ± 1.1	15.6 ± 1.2

Statistical analysis

The data obtained in experiments performed in triplicate were analyzed. Each treatment yield and the mean (±SEM) were calculated.

Values were expressed as Mean ± standard error (±SEM). growth performance, body composition and hepatosomatic index were tested using one-way ANOVA and Duncan's multiplerange test was used for comparison of the mean values at the 5% level of significance using software SPSS (Version 16.0).

Results

Mean dissolved oxygen and temperature were 6.3 ± 0.37 mg/L and 16.1 ± 1.12°C, respectively during the experiment (Table 2).

There were no significant differences in final body weight of fishes fed diets including 5–20% dextrin and the control diet (animal and plant oil as energy supplier source) (p>0.05).

The maximum and the minimum increase in weight was 38.78 ± 11.32 % and 27.18 ± 5.16 % per day in fish fed with 10 and 15% dextrin, respectively. Specific growth rate (SGR) showed no significant difference in all treatments (p>0.05). Adding of dextrin to diets caused an increase in FCR in fishes but showed no significant difference (p>0.05) among treatments.

The hepatosomatic index was 2 – 3% of body weight in *A. baerii* fed with increasing levels of dextrin and did not show any significant differences (p> 0.05; Table 1).

The highest carcass protein level was observed in treatments with 10, 15 and 20 % dextrin that showed significant differences compared to control and treatment with 5 percent dextrin (p<0.05) (Table 3).

Table2: Formulation and proximate analysis of experimental diets for *Acipenser baerii* juveniles (% dry matter, DM).

Ingredients (g kg $^{-1}$)	**Diet 1**	**Diet 2**	**Diet 3**	**Diet 4**	**Diet 5**
Fishmeal	5300	5300	5300	5300	5300
Dextrin (%)	0	500	1000	1500	2000
Soy bean	1200	1200	1200	1200	1200
Meat meal	1400	1400	1400	1400	1400
Animal oil	500	385	275	163	50
Plant oil	500	385	275	163	50
Mineral mixture	200	200	200	200	200
Vit mixture	100	100	100	100	100
Histidine	50	50	50	50	50
Choline	100	100	100	100	100
Salt	20	20	20	20	20
Lysine	100	100	100	100	100
Lecitine	150	150	150	150	150
L- carnitine	5	5	5	5	5
Proximate composition					
Protein (%)	43.4	43.5	43.2	44.1	43.8
Fat (%)	16.8	17.1	16.9	16.3	17.1
Moisture (%)	12.1	11.8	11.5	12.5	11.8
Ash (%)	5.5	6.1	5.8	5.7	5.9

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Soy bean	1200	1200	1200	1200	1200
Meat meal	1400	1400	1400	1400	1400
Animal oil	500	385	275	163	50
Plant oil	500	385	275	163	50
Mineral mixture	200	200	200	200	200
Vit mixture	100	100	100	100	100
Histidine	50	50	50	50	50
Choline	100	100	100	100	100
Salt	20	20	20	20	20
Lysine	100	100	100	100	100
Lecitine	150	150	150	150	150
L- carnitine	5	5	5	5	5
Proximate composition					
Protein (%)	43.4	43.5	43.2	44.1	43.8
Fat (%)	16.8	17.1	16.9	16.3	17.1
Moisture (%)	12.1	11.8	11.5	12.5	11.8
Ash (%)	5.5	6.1	5.8	5.7	5.9

Table 3: Effects of diets on growth, food conversion rate and hepatosomatic index in *Acipenser baeri* during 8 weeks.

Diets Parameters	Experimental diets/dextrin levels				
	Diet 1 (0 %٠)	Diet 2 (5 %)	Diet 3 (10 %)	Diet 4 (15%)	Diet 5 (20%)
Initial body weight (g)	687± 0.9 ^{a}	685±^{a}20.9	692.1± 5.4^{a}	689.2± 7.1^{a}	689.3± 12.4^{a}
Final body weight (FW) (g)	920.4 ±23.4 ^{a}	877.1± 53.7^{a}	961.3±81.26^{a}	880.7± 31.4^{a}	880.4± 10.8^{a}
Body weight index (BWI) (percent/day)	7.5^{a}±34.1	27.9± 4.25^{a}	38.7± 11.3^{a}	27.2± 5.2^{b}	27.7± 9.1^{a}
Specific growth rate (SGR) (percent/day)	0.47± 0.1^{a}	0.4± 0.1^{a}	0.5± 0.1^{a}	0.4± 0.1^{a}	0.4± 0.1^{a}
Food conversion rate(FCR)	4.42± 1^{a}	5.4± 0.7^{a}	4.1± 1.2^{a}	5.4±١ ^{a}	5.1± 0.9^{a}
Hepatosomatic Index	3.1± 0.6^{a}	2.9± 0.3^{a}	3.7± 0.9^{a}	2.1± 0.1^{a}	2.8±٠ 0.5^{a}

Values are expressed as means ± SEM of three replicate groups. No significant differences (p> 0.05) were detected between diets for the variables analyzed.

Table 4: Effect of food diets on body chemical composition in *Acipenser baerii* during 8 weeks.

Diets Indices	Experimental diets/dextrin levels				
	Diet 1 (0 %·)	**Diet 2 (5 %)**	**Diet 3 (10 %)**	**Diet 4 (15%)**	**Diet 5 (20%)**
Protein (%)	58.8± 0.4[c]	58.4± 0.0[c]	63± 0.0[a]	63.9± 0.0[a]	61.4± 0.1[b]
Fat (%)	27± 1.4[b]	29± 0.2[b]	33± 2.1[a]	19± 1.4[c]	34.5± 3.5[a]
Moisture (%)	69.2± 0.6[a]	69.7± 0.5[a]	69.2± 2.8[a]	72.4± 1.6[a]	70.1± 1.7[a]
Ash (%)	3.5± 0.0[b]	7.1± 0.6[a]	3.5± 0.0[b]	0.5± 0.0[c]	3.6± 0.2[b]

Values are expressed as means ± SEM of three replicate groups. Means in each line sharing a common superscript are not significantly different ($p > 0.05$).

Carcass lipid increased significantly with an increase in dextrin so that the highest lipid in carcass was observed in diets containing 10 and 20 % dextrin ($p<0.05$).

Experimental treatments showed no effects on carcass moisture ($p>0.05$). The highest amount of carcass ash was observed in fish in treatment 2 (containing 5 % dextrin) (Table 3).

Discussion

Fish fed on diets properly, but FCR was high because of high food conversion rate in artificial diet and low water temperature (Brendan *et al.,* 1988). In this study growth parameters and food conversion rate in fish fed with high levels of dextrin (20%), showed no significant difference in comparison with control. Sturgeon capability in carbohydrates utilization varies in different species (Hung *et al*., 1989). *A. transmontanus* utilizes D- glucose better than dextrin, corn crude starch, fructose, sucrose and lactose, but Kaushik *et al.* (1989) reported that *A. baerii* (90 – 150g) cannot utilize crude starch, while replacement of gelatinized starch or extruded starch with crude starch partly caused growth development. In this study, it seems that using of hydrolyzed carbohydrate and dextrin caused to increase its digestibility and absorbance and energy utilization that are according to Hung *et al*. (1989).

Hydrolyzed dextrin is better than starch because of better exposure to amylase enzyme in digestive tract and therefore its digestion is simple. Hilton *et al*. (1982), showed that the highest digestive carbohydrate levels (glucose) in *Oncorhynchus mykiss* is 25% according to other reports on Chinook salmon (Bergot, 1979), *A. tranmontanus* fed dextrin (Fynn- Aikins *et al*., 1992) and it is suggested that nutrients in fish diets must be balanced. These fishes can utilize and digest carbohydrate preferably.

Lipid and protein of carcass increased with an increase in dextrin in fish diet. The increase in carcass lipid in this study was similar to Fynn-Aikins (1992) who reported that an increase in D-glucose equal to 21 and 35% led to an increase in lipidogenesis enzyme activity in liver, and lipid deposition in visceral and tissues of *A. transmontanus*. These results were according to results obtained in *A.*

transmontanus (Hung *et al.*, 1989) and *Oncorhynchus mykiss* (Hilton and Atkinson, 1982), but in this study carcass protein and energy was increased.

Hepatosomatic index in all treatments showed no significant difference and liver were colorless so that glycogen deposition in liver was observed in *A. transmontanus* fed on diets containing 25 – 35% glucose and 27% dextrin, but no histological and histopathological damages were observed (Hung *et al*., 1989; Fynn-Aikins *et al.*, 1992).

Zamora-Sillero *et al.*, 2013 showed that the growth of the juvenile Lebranche mullets was not affected by dietary treatments with increasing levels of carbohydrates. Although the experimental period lasted 34 days, the fish showed an approximate weight gain of 250% as reported by NRC, 2011 as the growth from which we can conclude a feeding trial. Zamora-Sillero *et al.*, 2013 indicated that 35% of dextrin could be included in the Lebranche mullet diet without growth impairment or negative effects on blood or hepatic parameters. Some authors have reported that when fish are fed with an excessive input of starch in the diet, a decrease in feed intake (FI) is observed because the energetic contribution of the dietcan regulates food consumption in fish (Erfanullah Jafri, 1998). This reduction in the FI could lead to a lower ingestion of other essential nutrients, thereby reducing growth (Ali and Jauncey, 2004). It is known that the ability of fish to use carbohydrates from ingested food varies among species and feeding habits (Hemre *et al.*, 2002). Omnivorous and herbivorous fish species have a better carbohydrate acceptance and show a greater protein sparing effect than carnivorous species (Hemre *et al.*, 2002). The omnivorous grass carp (*Ctenopharyngodon idella*) can tolerate an inclusion of 33% wheat starch in the diet without affecting the growth and digestibility of dietary protein and carbohydrate (Tian *et al.*, 2012). Tan *et al.*, 2009 reported that for optimum growth, a maximum of 32% dietary starch could be included in the diet of gibel carp (*Carassius auratus*). In contrast, carnivorous fish have a lower acceptance of dietary carbohydrates. In the diet of the stripped murrel, *Channa striatus*, it was reported that a maximum of 12% dietary carbohydrates is allowed for optimal growth (Arockiaraj *et al.*, 1999).

The inclusion of dietary carbohydrates can potentially promote an improved utilization of the protein offered in the diet as well as an increased growth performance, as occurs with tilapia, *Oreochromis niloticus x O. aureus* (Shiau and Peng, 1993); fingerling rohu, *Labeo rohita* (Satpathy and Ray, 2009); and pacu, *Piractus mesopotamicus* (Abimorad and Carneiro, 2007). Growth promotion and protein sparing may be related to the fact that glucose is the preferred oxidative substrate for nervous tissue and blood cells, and the carbohydrate present in fish diets can depress gluconeogenic activity, thus diverting amino acids away from oxidative pathways (Cowey *et al.,* 1977; Sanchez-Muros *et al.*, 1996; Hemre *et al.,* 2002). However, the PER showed no significant variation among the dietary treatments. Thus, in this study increasing levels of dietary dextrin did not present the protein sparing effect. Some authors have reported that high levels of dietary carbohydrates can lead to an increase in blood glucose levels (Hemre and Hansen, 1998; Hemre *et al.*, 2002). The utilization of high levels of dietary digestible carbohydrates did not affect the long-term glycemic response in the Lebranche mullet. However, there are no previous works evaluating the glicated haemoglobin in fish or ectoterm animals (Zamora-Sillero *et al.*, 2013).

In hepatic tissue, the excess glucose derived from feeding results in either glycogen synthesis or lipogenesis (Tan *et al.,* 2009). Liver size and the hepatosomatic index (HSI) of the Lebranche mullets were not affected by the dietary treatments. However, liver glycogen content increased when the dietary dextrin levels increased from 15 to 25%. In addition, when the dietary dextrin level increased from 25 to 35%, the accumulation of hepatic triglycerides increased (Zamora-Sillero *et al*., 2013). Lipogenesis could be activated as the amount of dietary dextrin increased from 25 to 35%. This increase in the lipid content of the liver may imply that a large portion of the carbohydrate was used as energy. Thus, the Lebranche mullet is possibly well adapted to the higher carbohydrate level by increasing its glucose utilization (Zamora-Sillero *et al.,* 2013).

In fish culture practices, carbohydrate is the least expensive energy source and should be used intensively to improve dietary protein utilization and save costs when fish growth and the food conversion ratio are not depressed (Tan *et al.,* 2009). From this study, we can conclude that *Mugil liza* juveniles can be fed diets containing up to 35% dietary dextrin without deleterious effects on their growth or their plasma and hepatic biochemistry parameters.

Totally, with regard to results on liver and growth parameters it can be concluded that feeding of *A. baerii* with diets containing 15–20% carbohydrate is possible and therefore it is advised to carry out more studies on the replacement of cheap sources of carbohydrate instead of diet lipid partly in the future.

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